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Wear-Resistant Coating and a Component Having a Wear-Resistant Coating

The present invention relates to a wear-resistant coating, in particular an erosion-resistant coating, preferably for gas turbine components according to the preamble of Patent Claim 1. In addition, the invention relates to a component having such a wear-resistant coating according to the preamble of Patent Claim 13.

Components that are exposed to high fluidic loads such as gas turbine components are subject to wear due to oxidation, corrosion and erosion. Erosion is a wear process caused by solids entrained in the gas flow. To prolong the lifetime of components exposed to fluidic loads, wear-resistant coatings, also known as armoring, to protect the components from wear, especially erosion, corrosion and oxidation, are required.

European Patent EP 0 674 020 B1 describes a multilayered erosion-resistant coating for surfaces of substrates. The erosion-resistant coating disclosed there provides a wear-resistant coating consisting of several multilayer systems applied to the substrate to be coated. For example, in European Patent EP 0 674 020 B1, the multilayer systems that are applied in repeating layers are formed from two different layers, namely first a layer of a metallic material and secondly a layer of titanium diboride. Since the multilayer systems applied repeatedly to produce the erosion-resistant coating according to European Patent EP 0 674 020 B1 are formed of only two layers, alternating layers of metallic material and layers of titanium diboride are arranged in the erosion-resistant coating disclosed there.

European Patent EP 0 366 289 A1 discloses another erosion-resistant and corrosion-resistant coating for a substrate. According to European Patent EP 0 366 289 A1, the wear-resistant

coating is formed from multiple multilayer systems applied repeatedly to the substrate to be coated, each multilayer system in turn consisting of two different layers, namely a metallic layer, e.g., made of titanium, and a ceramic layer, e.g., made of titanium nitride.

Another erosion-resistant and abrasion-resistant wear-preventing coating is known from European Patent EP 0 562 108 B1. The wear-resistant coating disclosed there is in turn formed from multiple multilayer systems applied repeatedly to a substrate to be coated. Figure 4 in European Patent EP 0 562 108 B1 discloses a wear-resistant coating formed by several multilayer systems applied repeatedly, each multilayer system in turn consisting of four layers, namely a ductile layer of tungsten or a tungsten alloy and three hard layers, whereby the three hard layers differ with regard to the presence of an additional element.

Hence this background, the problem on which the present invention is based is to create a novel wear-resistant coating and a component having such a wear-resistant coating.

This problem is solved by improving upon the wear-resistant coating defined in the preamble through the features of the characterizing part of Patent Claim 1. According to this invention, each of the multilayer systems applied repeatedly has at least four different layers. A first layer of each multilayer system facing the surface to be coated is formed by a metallic material adapted to the composition of the component surface that is to be coated. A second layer of each multilayer system applied to the first layer is formed by a metal alloy material adapted to the composition of the component surface to be coated. A third layer of each multilayer system applied to the second layer is formed by a gradated metal-ceramic material and a fourth layer of each multilayer system applied to the third layer is formed by a nanostructured ceramic material.

The inventive wear-resistant coating ensures very good erosion resistance and oxidation resistance and has an extremely low influence on the vibrational strength of the coated component. It is suitable in particular for coating complex components such as guide vanes, rotor blades, guide vane segments, rotor blade segments and integrally bladed rotors.

Several such multilayer systems are applied repeatedly to the surface of the component exposed to fluidic loads, with an adhesive layer preferably being applied between the surface of the component and the first multilayer system directly adjacent to the surface.

The inventive component having such a wear-resistant coating is defined in the independent Patent Claim 13.

Preferred refinements of the present invention are derived from the subclaims and the following description. Exemplary embodiments of the present invention are explained in greater detail below with reference to the drawing, although they are not limited to these embodiments. They show:

Figure 1 a highly schematic diagram of a blade of a gas turbine having an inventive wear-resistant coating;

Figure 2 a highly schematic cross section through an inventive wear-resistant coating according to a first exemplary embodiment of the invention;

Figure 3 a highly schematic cross section through an inventive wear-resistant coating according to a second exemplary embodiment of the invention; and

Figure 4 a highly schematic cross section through an inventive wear-resistant coating according to a third exemplary embodiment of the invention.

The present invention is explained in greater detail below with reference to Figures 1 through 4. Figure 1 shows a blade of gas turbine in a perspective view having an inventive wear-resistant

coating. Figures 2 through 4 show schematic cross sections through the blade, each having different inventive wear-resistant coatings.

Figure 1 shows a blade 10 of a gas turbine with a blade pan 11 and a blade foot 12. In the exemplary embodiment in Figure 1, the entire blade 10, namely a surface thereof to be protected, is coated with a wear-resistant coating 13. Although the complete blade 10 is coated with the wear-resistant coating in the exemplary embodiment shown here, it is also possible for the blade 10 to have the wear-resistant coating 13 in only some sections, i.e., only in the area of the blade pan 11 or in parts thereof or in the area of the blade foot 12. Other gas turbine components such as the housing or the integrally bladed rotors such as blisks (bladed disks) or blings (bladed rings) may also be coated with the wear-resistant coating 13.

In Figure 2 the component to be coated is labeled with reference numeral 10. The inventive wear-resistant coating 13 is applied to a surface 14 of the component 10 to be coated. In the exemplary embodiment in Figure 2, the wear-resistant coating 13 consists of two multilayer systems 15 and 16 applied repeatedly to the surface 14. Each of the two multilayer systems 15 and 16 consists of four different layers, a first layer 17 of each multilayer system 15 and 16 facing the surface 14 to be coated being formed from a metallic material adapted to the composition of the component 10 to be coated. A second layer 18 of each multilayer system 15 and 16 applied to the first layer 17 is made of a metal alloy material adapted to the composition of the component 10 that is to be coated. A third layer 19 of each multilayer system 15 and 16 applied to the second layer 18 is made of a gradated metal-ceramic material, and a fourth layer 20 of each multilayer system 15 and 16 applied to the third layer 19 is made of a ceramic material. The gradated metal-ceramic material within the layer 19 forms a transition between

the second layer 18 and the fourth layer 20, namely from the metal alloy of the second layer 18 to the ceramic material of the fourth layer 20.

In the exemplary embodiment of Figure 3, another multilayer system 21 is applied to the multilayer system 15 and 16 described above, this additional multilayer system corresponding to the multilayer systems 15 and 16 with regard to the design of the individual layers 17 through 20. It is also possible to provide 4, 5 or a greater number of such multilayer systems 15, 16 and/or 21 repeatedly one above the other to form an inventive wear-resistant coating 13. The multilayer systems may also be formed, i.e., assembled from more than four layers.

In the exemplary embodiment in Figure 4, an adhesive layer 22 is applied between the surface 14 of the component 10 to be coated and the first multilayer system 15 adjacent to the surface 14. The adhesive layer 22 permits better contact between the inventive wear-resistant coating 13 and the component 10 that is to be coated.

The concrete design of the individual layers 17 through 20 of the multilayer systems 15, 16 and 21 is adapted to the material composition of the component 10 that is to be coated. A few examples here:

In the case of a component 10 that is to be coated and is made of a nickel-based material or a cobalt-based material or an iron-based material, the first layer 17 is preferably designed as a nickel layer (Ni layer). Then a second layer 18 made of a nickel-chromium material (NiCr layer) is applied to such a Ni layer 17. Then, as the third layer 19, a gradated metal-ceramic layer is applied to the second layer 18 of nickel-chromium material, whereby the metal-ceramic layer is preferably made of a CrN_{1-x} material (CrN_{1-x} layer). The fourth layer 20 is formed by a ceramic material, namely chromium nitride (CrN layer).

According to another example, the component 10 to be coated is made of a titanium-based material. With such a component 10 that is to be coated and is made of a titanium-based material, the first layer 17 is preferably made of titanium, palladium or platinum. Then a second layer 18 formed by a TiCrAl material or a CuAlCr material is applied to such a first layer 17. This is then followed by a third layer 19 which is a gradation layer formed either from a $CrAlN_{1-x}$ material or a $TiAlN_{1-x}$ material. In the case when the gradation layer 19 is formed by a $CrAlN_{1-x}$ material, the fourth layer 20 is a CrAlN layer as a ceramic layer. In the case when the gradation layer 19 is formed by a $TiAlN_{1-x}$ material, the fourth layer 20 is preferably made of titanium aluminum nitride (TiAlN). Instead of the titanium aluminum nitride material, in this case, however, a TiAlSiN material or an AlTiN material or a TiN/AlN material may be used as the ceramic material for the fourth layer 20.

The inventive wear-resistant coating 13 is applied to the component 11 that is to be coated in the sense of the present invention by means of a PVD coating process. The layer thickness of a multilayer system of the inventive wear-resistant coating preferably amounts to less than 15 μm.

The inventive wear-resistant coating is preferably used for complex three-dimensional components exposed to high fluidic loads such as housing elements, guide vane segments, rotor blade segments, integrally bladed rotors or individual blades for aircraft engines. The entire component or just an area of same may be coated with the wear-resistant coating according to this invention.